Flexines' role model extensions for the smart energy market

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1 Introduction

The energy value chain[1] will see a number of significant changes in the near to midterm future. The existing value chain has to cope with the growing energy demand and the inclusion of decentralized intermittent renewable energy resources. In addition, there are other important changes on the horizon:

- **Decentralized production**: The existing *value chain*, largely characterized by centralized energy production and decentralized consumption, will have to change to *a value network* with a significant, and increasing, amount of decentralized energy.
- **Renewable and intermittent**: The long term depletion of fossil fuels and the dependency on a small number of production regions will affect the shift to an ultimately very substantial share of renewable resources
- **Driven by availability of energy**: when a larger share of energy will be provided by intermittent energy resources, the organization of energy supply will have to change from a situation where supply is shaped to meet demand, to a situation where demand is shaped by supply; i.e. energy must be used when it is available.
- **Market liberalization**: The market (and thus the value chain) changes significantly due to market liberalization (changing regulation, changing set of market parties) and internationalization.
- **SMART**: ICT (Information and Communication Technology) is introduced for managing – often automatically – many aspects of the future energy infrastructure. This includes sensors, actuators and logic to add intelligence to existing or new infrastructure and appliances.

These changes will require a value chain or value network and underlying technical infrastructure, which in many places will be significantly different from how it is structured and organized today. The main challenge is to transform it to a sustainable energy value network. A lot of research and hard work will be needed to design and organize the future energy network.

1.1 In this paper

In this paper we focus on the inclusion of decentralized energy production in the current energy infrastructure, and the changing role of the consumer towards a producer and an active participant in the energy value network. We discuss the following items:

- Energy role models: what is a role model, what are existing energy role models, and why do we need a new one?

[1] Wikipedia: A value chain is a chain of activities for a firm operating in a specific industry. Activities within a value chain are mostly strictly ordered and tightly coupled. Whenever the activities are more loosely coupled, we speak of a value network

- The Flexines role model, consisting of three views: commercial, physical, metering &billing.
- All actors in the role model: per actor there is a relation with other actors in the
    - Physical view
    - Commercial view
    - Metering & billing view
- Reflection: on the Flexines role model in relation to the other role models
- Conclusions

2 Energy role models

For the Flexines project, we developed a new role model, because the existing models did not completely cover the activities and functionalities encountered during the project. In this chapter a brief description of two existing European role models will be given, followed by a section which explains why we developed a new role model with different views.

2.1 What is a role model ?

A role model describes the various roles that cooperate to fulfill a specific functionality or service. Each role contributes a functional element and adds value, which is necessary to collaboratively form a value chain or a value network. Each role can be fulfilled by one or more parties (i.e. company, customer), while one party can fulfill multiple roles.

2.2 Existing role models

For modeling the energy market, a number of important role models are available. We primarily looked at two models[2] produced by two organizations:

- TenneT (http://www.tennet.org/english/index.aspx) a Dutch cross-border grid operator for both electricity and gas, and
- ENTSOE (http://www.entsoe.eu): European Network Transmission System Operators for Electricity, a cooperation between European transmission network operators, including TenneT .

Both role models were developed for specific purposes and as such each model has its specific focus. In the next paragraphs the two role models will be briefly described.

2.2.1 The TenneT model

The TenneT model [1] is used to indicate “the relationships among various players in the energy sector in the Netherlands”. The important roles are identified and the mutual relations are shown. The model is an accurate representation of the current situation on the Dutch energy market (see Figure 1). For the sake of simplicity only the electricity roles are depicted. For the gas market similar roles in a similar structure can be identified.

[2] We also looked at the model proposed by NIST (http://www.nist.gov/smartgrid/upload/NIST_Framework_Release_2-0_corr.pdf) but we decided to concentrate on proposals in the European context first. As a consequence, we did not further investigate the NIST model in this paper.

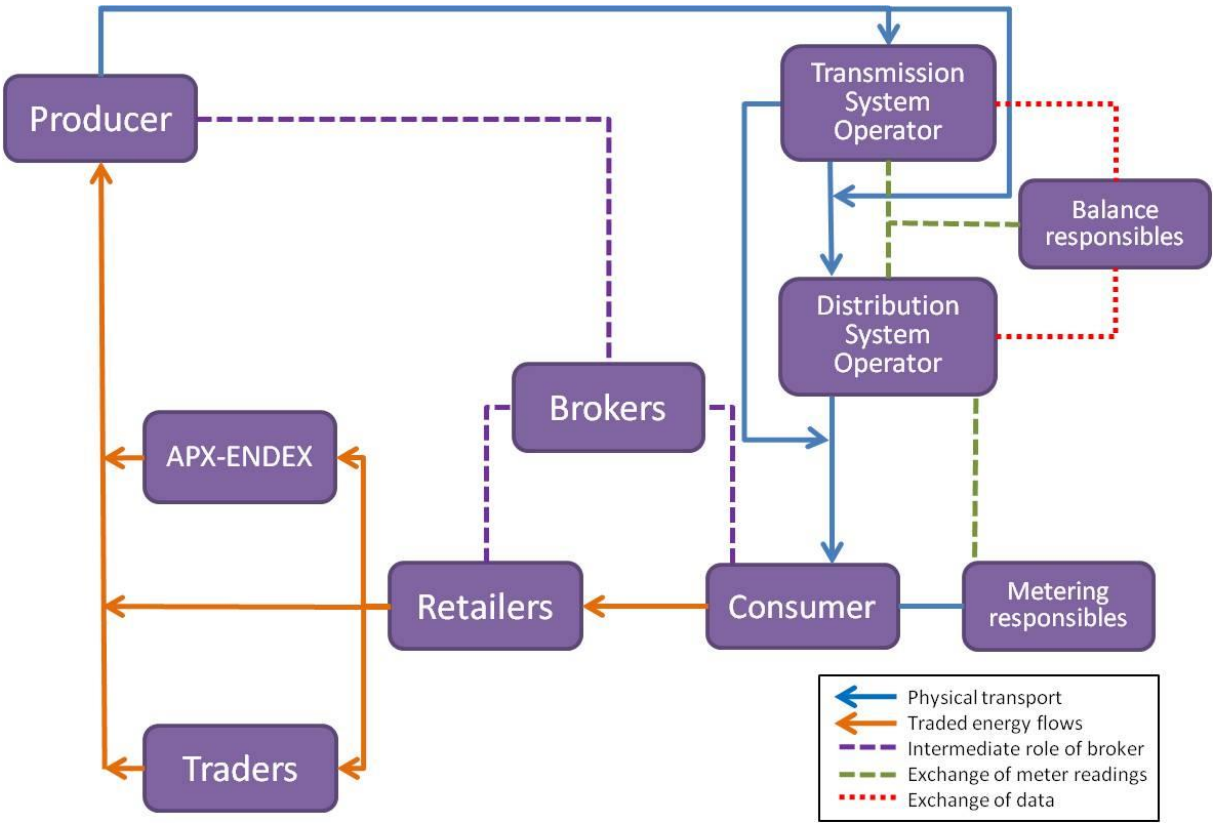


Figure 1: The TenneT role model

Starting in 2004, the Dutch energy market has been operating in a fully liberalized manner. According to Dutch law and EU regulations, the network operators and the networks under their supervision may no longer belong to a company that also supplies and/or produces energy. Ownership of the physical networks has been transferred towards public shareholders, so the network operators fulfill an independent role in the energy market. In Figure 1 the network operators are represented by the roles of the Transmission System Operator and the Distributed System Operator.

TenneT is the Transmission System Operator for northwestern Europe, playing an important role in the energy value chain of that area. TenneT and its partners need to have a good understanding of how their businesses interact. However, the TenneT model is energy demand driven (energy is supplied when energy is demanded) instead of supply driven.

2.2.2 ENTSOE

The ENTSOE model [2] “has been developed in order to facilitate the dialogue between the market participants from different countries through the designation of a single name for each role and domain that are prevalent within the electricity market. Its focus is essentially to enable a common terminology for IT development”.

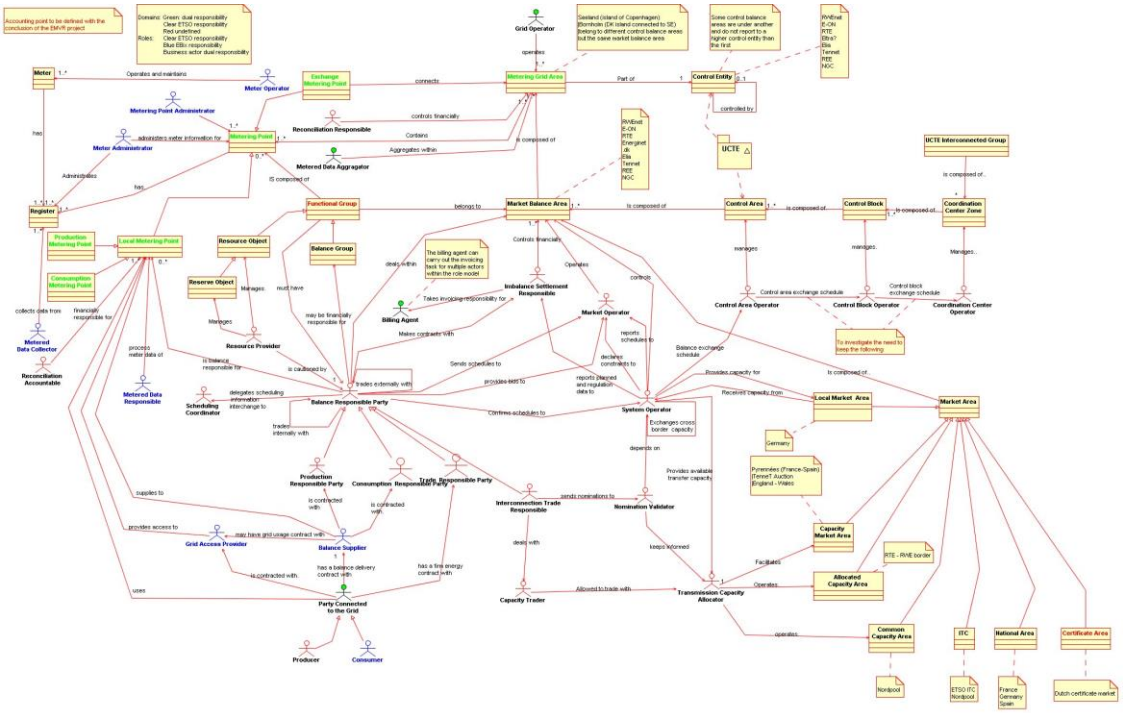


Figure 2: The ENTSOE role model

The ENTSOE role model, as depicted in Figure 2, aims to cover almost all aspects of the electricity network, ranging from wholesale and retail markets, to metering and billing, and to network control. The role model focuses on typical ICT aspects, such as interfaces, information exchange (covering semantics and syntax of messages) and (ICT parts of) business processes. As a consequence, the model is quite extensive and complex because of the (ICT) details.

2.3 Flexines – household of the future

The Flexines project assumes that the market will become much more liberalized and flexible than it is today. Decentralized small-scale energy production and local energy trading will become common place. Negotiations between partners (consumers vs producers) are more likely to take place on a local level with small local partners, and with shorter timeframes established in energy contracts – related to short term weather forecasts. As a consequence new roles in the role model are expected to appear. Such roles are not depicted in the current ENTSOE or TenneT models – which reflect today's world.

In the Flexines vision, a household of the future will be a household with both energy consuming and energy producing[3] appliances (both gas and electricity). Such a household concept corresponds to TenneT's "consumer" and "producer", and to the ENTSOE's "party connected to the grid".

In the future, a household will be able to predict its energy consumption or energy production patterns for the near-term future (e.g. 24 hours, with typically 15 minutes time intervals). To make such forecasts various methods can be used, ranging from techniques based on weather forecasts, to the analysis of historical data of energy consumption and production within a household.

[3] Households in the future will be equipped – to a larger extent than today – with energy producing appliances such as PV panels and microCHPs.

A future household will be an active participant on the energy market: based on predictions, the household can trade on a (possibly local) energy market with the aim of buying and/or selling its energy. On this market, households can also buy from and sell energy to other households in their own vicinity (typically street or neighborhood). Any sales on the market will be established in contracts, which form the basis for financial settlements mechanisms.

Based on real time energy prices on the market, the household will be able to shift its energy consumption and production patterns. Due to the short term nature for reliably predicting energy demand and supply, prices on the market will fluctuate frequently (for example, every 15 minutes[4]) and trading contracts will often be for relatively short time periods.

If a household cannot make a favorable deal, a "supplier of last resort" is always available, which presumably will lead to higher prices for the energy bought.

2.4 Why a new role model?

We introduce the Flexines role model, because

- **Future vision**: Our focus is based on a vision of the future in which households play a more prominent role in the energy value chain. Households will effectively be "Parties connected to the Energy Market", who combine the energy consumer and energy producer roles. However, the TenneT and ENTSOE flavors for these concepts do not quite "match".
- **End user perspective**: The Flexines project takes the end user (future households) perspective as a starting point. Therefore only roles that interact directly with the end user are being considered.
- **Driven by commercial considerations**: A key concept in Flexines is that households actively participate on the energy market, and that they can schedule their energy consumption and production based on fluctuating prices – for specific timeslots – on the energy market. Households negotiate commercially about energy delivery, both in their role as a producer and a consumer. Energy only flows between roles when commercial contracts have been established[5]. This interaction on both the commercial level and on the physical level is not clearly visible in neither the TenneT nor the ENTSOE role model[6], which made these models not very suitable for our project.
  For Flexines it was also necessary to explicitly represent contracting and billing streams – especially, those involving households - which are not (TenneT) – or insufficiently (ENTSOE) - available in the other models.
- **Growing importance of value added services**: In addition, we wanted to model new roles on the energy market (energy service providers), which provide value added services, in addition to basic energy supply, to other roles in the model.

Essentially, for the Flexines project, we needed a future proof view, which allows for an easier way to express that different parties "negotiate" with one another to establish contracts for energy supply and demand and related (value adding) services at a local level.

[4] Current practice on wholesale markets.
[5] The Flexines project does foresee a "supplier of last resort" with a "generic" contract, to deliver energy if no other deals can be established. However, prices of the supplier of last resort are expected to be significantly higher.
[6] Within ENTSOE, a "party connected to the grid" can be either a producer or a consumer.

3 The Flexines role model – overview of the three views

In the previous chapter we argued why there is a demand for a new role model. This chapter introduces the different views making up the Flexines role model. These are:

- The physical view
- The commercial view
- The metering & billing view.

A future proof role model for energy supply and demand to end-users must reflect a number of different relationships (see Figure 3). First of all, there is the *physical relationship*, reflecting how a household is physically connected to the energy network.

In addition to the physical relation, a commercial relation exists. The commercial relation represents the contracts between the household and a so called Energy Service Provider (ESP).

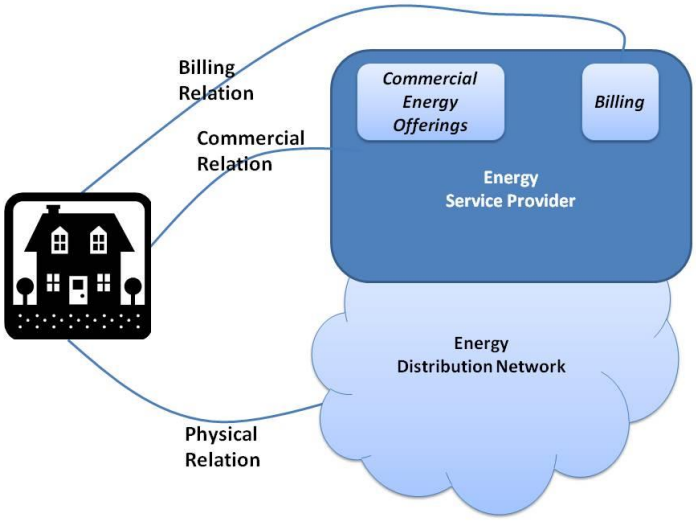


Figure 3: The Flexines role model, reflecting the various types of relations

The ESP is the contract partner of the end user and the one who provides value added services, in addition to energy delivery. Such contracts typically describe quantities of energy (both consumption and production), prices of energy, available connection capacity, payment conditions, conditions for service etc.. Nowadays, households typically can choose their energy contracts from a number of different energy retailers, with sometimes significant differences between contracts conditions offered. We expect that there will be even more choices and options in the near future.

A household may also purchase energy related services from an energy service provider. Such services could range from weather forecasts (to improve energy usage/generation forecasts) to efficiency advice to operational service contracts. In turn, households could also offer services, for example renting energy storage capacity to the network.

Finally, based on contracts and metering information reflecting the physical usage of energy, the household receives invoices from the energy service provider's billing function. Based on the payments made by the households, revenues will be distributed to all participants in the value chain involved to cover for operational costs and provide a reasonable operational margin. The ESP acts as an intermediate between the end users and the other roles in the value network, and therefore is responsible for the financial transactions.

For each of the three relationship types (physical, commercial and metering & billing), the Flexines role model provides a separate "view". An overview of these views is given in the following subsections. The various roles, and their mutual relations, are described in more detail in chapter 4.

Note that important parts of the relationships are determined by an overall legal and regulatory framework, which effectively is different in every country. We do not further address or model the legal and regulatory aspects in this paper, while that is out of the scope of the Flexines project.

3.1 Physical view

The Flexines role model starts with a view reflecting the physical connections in the energy market, with the aim to model household level energy consumption and production (Figure 4).

The energy bought and sold by the household has to be physically transported through the energy grid, and as such this view contains the roles "energy producer" and "energy consumer" (in short, producer and consumer), as well as the roles representing the Transmission System Operator (TSO) and the Distribution System Operator (DSO).

The TSO represents the (long distance) transmission network (high voltage for electricity) and the DSO the – more locally oriented – distribution network (medium and low voltage for electricity). Depending on the connection capacity of the producer or the consumer, such a "Party connected to the Grid" is connected either to the distribution network or to the transmission network.

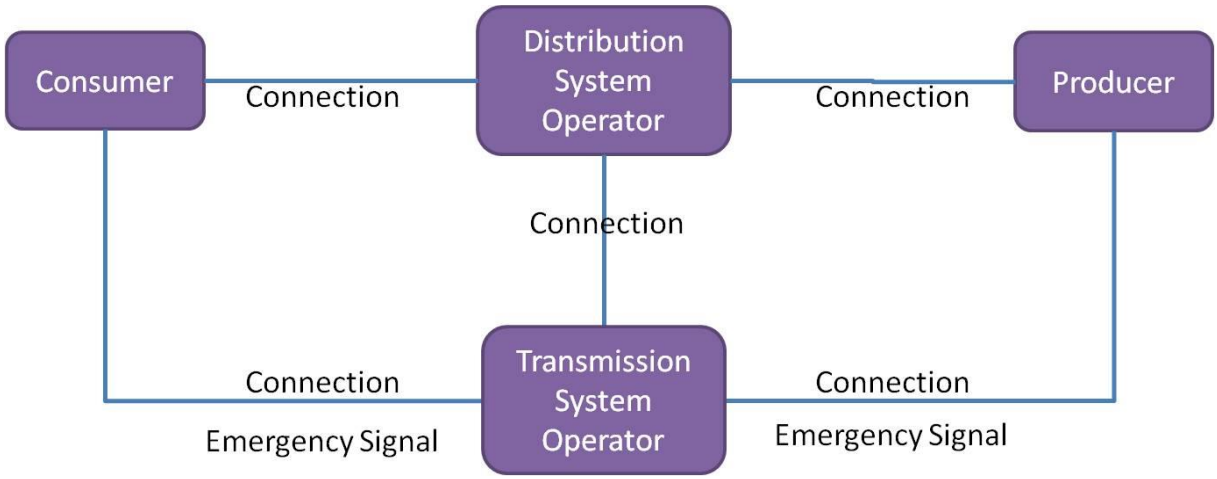


Figure 4: The Flexines role model – physical view

TSO and DSO have responsibilities such as transport of energy, security of supply, power quality, and balancing.

From a household perspective, a physical connection – with a specific energy capacity - is used to transport energy (electricity and gas) to (consumption) and from the household (production). Safety mechanisms (e.g. breakers) and metering mechanisms are in place for security (protection) and billing reasons.

3.2 Commercial view

The commercial view represents the roles that are involved in buying and selling energy in commercial transactions with other roles on the market (Figure 5). Each role in the chain adds value and each commercial transaction in this chain is the result of a number of negotiations to determine the desired price (and possibly some other conditions).

Within Flexines the focus is on the roles that a household could play on the future energy market. These roles include a traditional supply chain role as a consumer of energy. With households installing energy producing equipment, households[7] effectively become producers of energy, which can be offered on the market.

In a typical supply chain model, consumers buy from retailers and sell to traders. Retailers and traders are typical roles used in supply chain models, their value is in distribution (retailers) to many small scale energy consumers, and - inversely - collection (traders) of energy from many small scale energy producers.

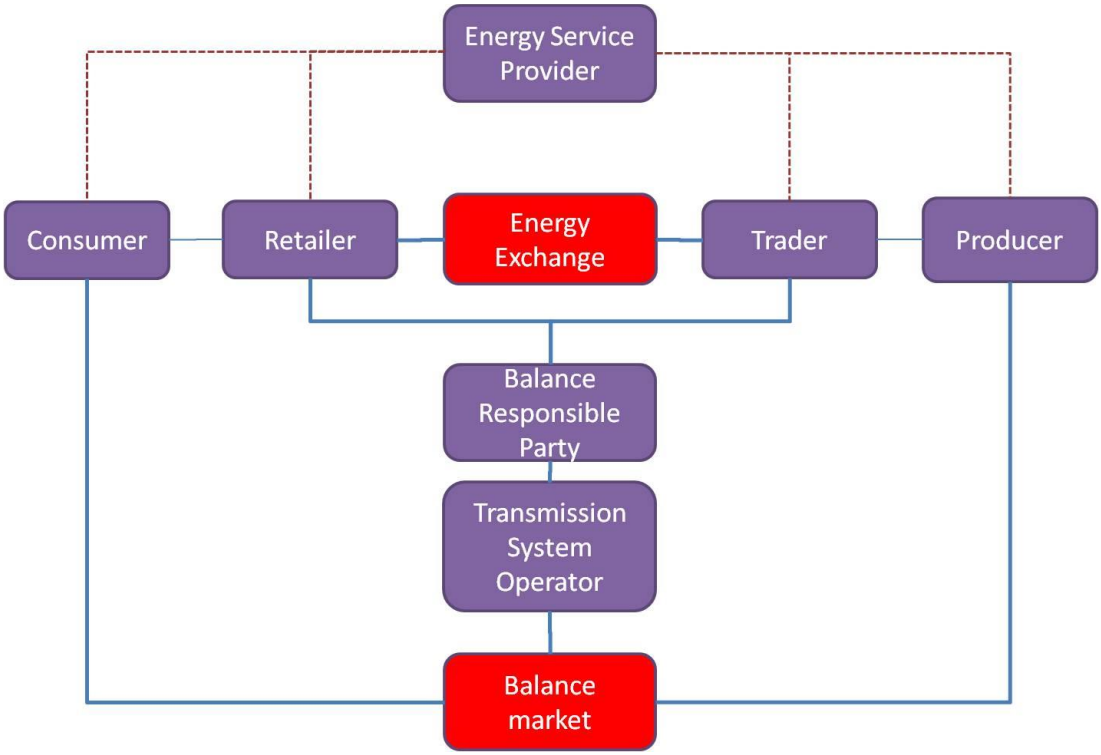


Figure 5: The Flexines role model – commercial view

In the Flexines role model, retailers specialize in reselling large volumes of a product – bought on the energy market - to consumers. Traders specialize in purchasing energy from producers and bringing these volumes to the market. The value that these roles add is in organizing the collection and distribution of energy from many producers to many consumers on both the physical and the commercial level.

The balance responsible party is responsible for shipping traded quantities from traders (indirectly producers) to retailers (indirectly consumers). The balance responsible parties utilize the transmission network operated by the TSO.

[7] Although the Flexines project focuses on households, the role model also applies to small and medium businesses. For example, many Dutch greenhouse farmers purchased CHPs or GasTurbines that are used both to heat the greenhouses and to sell electricity to the network in time of energy shortage on the network, in combination with favorable prices.

The Balance Market is a market where last minute corrections can be effected to establish balance on the network. In case of a shortage either producers will be asked to generate more energy or consumers will be asked to lower their consumption. In case of a surplus either consumers will be asked to increase their consumption or producers will be asked to lower their production.

3.3 Metering and billing view

Finally, all the energy transactions have to be metered, billed and paid for. Within the Flexines model we decided to introduce separate roles for metering and billing services (see "Metering and Billing view", Figure 6).

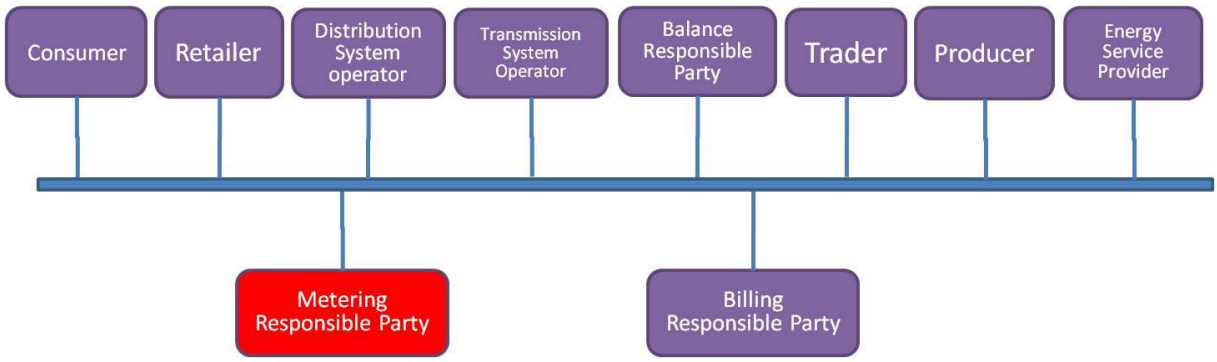


Figure 6: The Flexines role model – metering and billing view

In the commercial view (Figure 5), energy contracts are established between the various roles. In our role model, these contracts will be sent to a Billing Responsible Party. In many of these contracts, quantities are defined by metered usage data, that becomes available at the network connection points. The metering and billing view reflects that such metered data is collected (at the appropriate network connection points) and sent to a metering responsible party.

The metering responsible party (1) collects all relevant metered data, (2) ensures that meter data is correct, (3) produces meter aggregates for each connection point and (4) distributes the meter aggregates to the relevant billing responsible party.

The billing responsible party is responsible (1) for creating all the relevant invoices (based on contract information and metered data) and (2) for paying and collecting all the due money.

In reality, many organizations will fulfill a number of different roles, which may include their own billing responsible party. Households may decide to do their own administration and billing (especially when they start to produce energy), but it may be more appealing to outsource this work to specialized "billing factories".

4 Overview of all actors and their relations

This section describes each of the actors, and their interrelations in the various views of the Flexines model. Note that market parties may at the same time represent multiple roles in the model. A company, as it exists today, could be a producer, a trader and a balance responsible party at the same time.

4.1 Consumers

4.1.1 Physical view

The consumer role largely represents the traditional household - or small-volume user - connected to the energy distribution network. Households today essentially are consumers of gas and/or electrical energy and sometimes heat (*heat trade and distribution is out of the scope of the Flexines project*). However, larger scale consumers (small, medium or large businesses) are also covered by this role.

On a physical level (Figure 4), the consumer is connected to the distribution network of the Distribution System Operator (DSO). Larger volume consumers can be connected to the network at other network levels – represented by the link between the consumer and the Transmission System Operator (TSO).

As part of the physical infrastructure at the interface between the distribution network and the consumer – a circuit breaker will cut power in case of a technical emergency (for example in case of a short circuit). One could imagine that more intelligent control points might enable it to throttle power consumption of the consumer. Such throttling could be triggered by a network emergency signal or based on other triggers, for example, for non-payment or violation of connection contract conditions.

In a smart grid, with automated energy management mechanisms, the energy consumption of a household can be influenced, depending on the flexibility of the devices in the household. In situations where there is an imbalance in the network, households can be asked to reduce (or increase) their energy consumption to counteract the imbalance[8]. By allowing (or requiring!) the consumers to participate on the balance market – for a certain part of their energy consumption – they can become an integral part of the stabilization functionality on the network.

4.1.2 Commercial view

A consumer buys energy from a retailer, which is represented by *a commercial relation*. Such energy purchases are administered as energy contracts, specifying volumes, time frames, prices and other relevant aspects of each energy deal. Each contract is the result of a negotiation process, where both “calls for proposals” and “proposals” are exchanged until an agreeable deal is made.

The retailer is the single-point of contact for the consumer, which is materialized in the contract, the yearly bill settlement, and eventually an online portal. A consumer is free to choose the retailer that best suits his needs. Today a consumer can choose from a broad range of commercial offerings from a large number of different retailers. The main reason for switching to another retailer will be the price of energy, or the extra services being offered.

In addition to the commercial relation with the retailer, the consumer may have a commercial relation with an energy service provider (see also section 4.10.2). The energy service provider might become the single-point-of cont(r)act for the consumer.

4.1.3 Metering & billing view

The physical connection with the distribution network is formed by an energy meter – which is the property of the Metering Responsible Party. The meter measures the amount of energy consumed by the consumer. The meter provides metered data of the energy consumption to the metering responsible party.

[8] Many different mechanisms can be envisioned. Small scale consumers could be given incentives to increase or decrease energy consumption through variable pricing.

In the Netherlands most households still have a mechanical meter, where meter readings are collected once a year. The large scale roll out of smart meters is planned for the period of 2012-2014. Smart meters allow for more frequent, distant meter readings to be established (up to one reading per second), allowing detailed, (near) real time monitoring of a household's energy consumption and production.

The smart meter not only provides the meter data to the Metering Responsible Party, but also to the consumer. A consumer could use these meter readings to gain insight into his energy usage and energy behavior. Moreover, the consumer could also use these meter readings to verify the invoices obtained from the retailers, traders or energy service providers.

The Metering Responsible Party can also provide metering data to other roles than the retailer and the DSO/TSO, for instance to a third party like an Energy Service Provider. This is only allowed when the consumer grants permission.

Based on the contract, and the contract and metering data available to the billing responsible party, the consumer receives invoices from and handles payments with the billing responsible party.

4.1.4 Local consumer community

In the future, groups of consumers might organize themselves to realize their own energy supply and demand at a local level. Hundreds of local energy initiatives [9]already have been established in the Netherlands, where members of the corporations are facilitated to collectively purchase production capacity (i.e. PV panels, corporate wind mill).

Eventually the corporation (or some other form of legal entity) will play the role of retailer or trader, buying and selling energy of /to its members, providing local energy balancing, and probably trading on the energy exchange whenever there is a local surplus or shortage, or in case of financial incentives.

Such local corporations pursue enough own production capacity for the community to be self-supportive, which allows them to be –to a large extent - independent from the incumbent energy suppliers. In "extreme cases" the local energy corporation can operate as a micro-grid, operating completely independent from the central grid. Micro-grid operation is only feasible when a 24-hour balance between supply and demand can be maintained, and security of supply is guaranteed.

4.2 Producers

In the current energy market, energy production mainly takes place in central, large scale energy production plants (63% central production [10]). However, distributed production is growing (36% production at MV-level and 0,5% production at LV-level), as well as the share of renewable sources. But still the share of renewable sources is behind schedule (4.2% in 2011[11]), which makes it difficult to reach the goal that is set by the EU for 2020: 14% of the total energy production should come from renewable sources.

4.2.1 Physical view

In the Flexines role model the consumer can also be a producer (the prosumer). The producer role produces energy, which includes production of electrical energy (E) and/or gas (G).

[9] In the Netherlands there are currently hundreds of initiatives where about 50 are actually operating as energy providers; often as a white label of a company with a permit to deliver energy (PV).
[10] Source, CBS 2011, presentation Alliander, 20 March 2012
[11] Source, CBS 2011

On the physical level (Figure 4), the producer is connected to the distribution network of the Distribution System Operator. Large(r) volume producers can be connected to the network at other network levels – represented by the link between the producer and the Transmission System Operator .

The energy meter forms the physical connection with the distribution network of the Distribution System Operator. The meter measures the amount of energy that is delivered to the grid. The meter provides metered data of the energy supply to the metering responsible party.

In a smart grid, with automated energy management mechanisms, the energy production of a household can be influenced, depending on the flexibility of the devices in the household. In situations where there is an imbalance in the network, households can be asked to reduce or increase their energy production to counteract the imbalance[12]. By allowing (or requiring!) the producers to participate on the balance market – for a certain part of their energy production – they can become an integral part of the stabilization functionality of the network.

4.2.2 Commercial view

Producers sell energy to a trader which is represented by a commercial relation (Figure 5). Such energy sales are administered as energy contracts, specifying volumes, time frames, prices and other relevant aspects of each energy deal. Each contract is the result of a negotiation process, where both "calls for proposals" and "proposals" are exchanged until an agreeable deal is made. A producer is free to choose the trader that best suits his needs. The main reason for selling to a specific trader will be the price of energy offered.

A producer, with a production capacity larger than 5 MW, has to reserve spare capacity that can be called upon by the TSO to balance the network [**Systemcode**]. Households are not expected to come close to this value, and therefore are not required to have such spare capacity available. However, when larger groups of households start to cooperate to form larger Virtual Power Plants, such spare capacity requirements may become relevant for these households too.

In addition to the commercial relation with the trader, the producer may have a commercial relation with an energy service provider (see section 4.10.2).

4.2.3 Metering & billing view

A producer provides measurement data about his energy production to the metering responsible party. When a producer has a mechanical meter, meter readings are sent to the metering responsible party once a year. Smart meters allow for more frequent meter readings (up to one reading per second) that are automatically sent to the metering responsible party. The metering responsible party provides input to the billing responsible party.

Based on the contracts established between traders and producers, and the available metered data, the producer receives (credit) invoices and payments from the billing responsible party.

4.2.4 Prosumer – the consumer as a producer

More and more individual households are investing in production facilities that fully or partly provides for their own electricity demand. In case of a surplus of production capacity the energy is delivered back to the distribution network of the Distribution System Operator and sold to their contracted trader. The surplus that is delivered back, is settled with the bill of consumed electricity, such that the consumer only pays for the net-delivered energy from the retailer (net-metering). The invoice

[12] Many different mechanisms can be envisioned. For example: small scale consumers could be given incentives to increase or decrease energy consumption through variable pricing.

specification may contain both the consumption data and the supply data, separately measured by the meters or it is just a single “net consumption” value.

4.3 Traders

4.3.1 Physical view

No physical connection involved.

4.3.2 Commercial view

A trader is trading energy at the energy market place (this could be the APX, or a locally oriented market place). The trader purchases large volumes of energy from the producers, based on predictions that are made on (future) demand, and sells the energy to retailers, who in turn provide the energy to the end-users. The trader’s responsibility is to contract producers to produce certain energy volumes at specified times under specified conditions, which may involve special clauses to control the production.

The contracted energy volumes are traded on the Energy Power Exchange (APX-ENDEX). The trader tries to maintain a trade margin whilst buying energy volumes from producers and selling these volumes on the exchange market to retailers. Traders and retailers may also make contracts outside of the APX-ENDEX (internal market).

Once the trader has sold his energy on the market, the trader informs the Balance Responsible Party (BRP) that the amount of energy that has been sold will be fed in on the producer’s connection.

The trader may also have a commercial relation with an energy service provider (see section 4.10.2).

4.3.3 Metering & billing view

A trader provides contractual information about each producer connected in his contracts to the billing responsible party. Based on such contractual data, combined with metered data from the producers governed by his contracts, the billing responsible party can calculate the amount of money that the trader “owes” the producers. In the same way, the billing responsible party calculates the contracts with the retailers, and is capable of determining how much money the retailers owe the trader. Various payment mechanisms may be used to settle the bills.

4.3.4 Traders considering prosumers at household level in the future situation

A trader buys energy from a number of different (household level) producers, utilizing typical retail style contracts. Potentially, prosumers combine themselves into an intermediate organization or a broker which sells their collective energy to a trader. Traders would have to purchase energy at the best prices and best conditions, and could provide different commercial offerings to the market of prosumers.

A prosumer is free to choose the trader that best suits his needs. Given that households will only have relatively short prediction periods (24 hours or less), those parties will establish contracts only with a short duration. Typically, producers and retailers will therefore regularly establish contracts with other parties, largely based on price; as a result, parties in contracts will continuously change, and long term relationships (as currently used) may be the exception rather than the norm.

4.4 Retailers

4.4.1 Physical view

No physical connection involved.

4.4.2 Commercial view

A retailer is trading energy at the energy market place (i.e. APX). The retailer purchases large volumes of energy from the traders, based on predictions that are made on (future) demand of its customers, and sells the energy to consumers. The retailer's responsibility is to contract traders to deliver certain energy volumes at specified times under specified conditions, which may involve special clauses to control the consumption.

The contracted energy volumes are traded on the Energy Exchange (APX-ENDEX or a locally oriented market). The retailer tries to maintain a trade margin whilst buying energy volumes from traders and selling these volumes to consumers. Traders and retailers may also make contracts outside of the APX-ENDEX (internal market).

A retailer buys energy from traders on the Energy Exchange and sells this energy to a (potentially) large number of consumers. The retailer usually offers consumers a relatively stable tariff for their energy over a longer period of time (typically yearly contracts). The retailer buys energy on the energy exchange in relatively short time slots (e.g. day, hour). The aim of the retailer is to do this in such a way that he retains a margin with respect to the energy that is sold to the consumers.

Through its Balance Responsible Party, the retailer informs the TSO about the contracts for energy delivery to allocate the required transport capacity.

In addition to this commercial relation with the retailer (through the exchange) and the consumer, the trader may have a commercial relation with an energy service provider (see section 4.10.2).

4.4.3 Metering & billing view

A retailer provides contractual information about each consumer connected in his contracts to the billing responsible party (**Figure 3**). Based on the contractual data, combined with metered data (metering responsible party) from the consumers governed by his contracts, the billing responsible party can calculate the amount of money that the consumers should pay to the retailers. In the same way, the billing responsible party calculates the contracts with the traders, and is capable of determining how much money the retailers should transfer to the traders.

4.4.4 Retailers considering prosumers at household level in the future situation

A retailer sells energy to a number of different (household level) consumers, utilizing typical retail style contracts. Potentially, consumers organize themselves into an intermediate organization (e.g. an energy community) which organizes a "collective purchase" deal with the retailers. Retailers would have to sell energy at the best prices and best conditions, and could provide different commercial offerings to the retail consumer market. Eventually the energy community could incorporate the role of retailer themselves.

A consumer or trader is free to choose the retailer that best suits his needs. The main reason for a consumer or trader to switch retailers will be the price of energy and the offering of value added services. However, other aspects may be considered too.

4.5 Energy exchange

Often, the trader and the retailer, and even the production role are available in a single organization (for example: Essent, NUON). It is important that energy supply and energy demand match and this matching is made visible in an additional role: the energy exchange (market).

Currently, three different energy markets - operating on a national level – can be distinguished, based on the trading timescale:

- Long term energy market
- Day ahead market – where trading takes place on one day before the delivery of electricity the next day
- Intra-day market – orders can be traded up to 90 minutes prior to delivery.

Within Flexines we look at a market concept where energy is exchanged at a local level, with time-frames up to 24 hours. The 24 hours timeframe is due to the reliability of the energy forecasts made by the households.

For large producers (more than 5 MW) a certain amount of spare capacity is reserved for balancing purposes and will therefore not be offered on the regular energy exchange.

4.5.1 Physical view

The Energy Exchange does not involve a physical relationship.

4.5.2 Commercial view

The energy exchange is the marketplace where volumes of energy are traded by the retailers and the traders. Traders offer energy volumes whereas retailers demand energy volumes.

The aim of the energy exchange is to match demand and supply for as large a volume as possible. The price of energy (as traded on the exchange) fluctuates per time slot based on whether there is a shortage (prices go up) or an oversupply (prices go down) of energy. Based on these fluctuating prices, the volumes of energy supplied and demanded also fluctuate, resulting in a dynamic market-place.

Any matches of supply and demand are reflected in contracts detailing the delivery (or retrieval) of energy on the network. They also contain aspects relevant for financial reconciliation such as the prices for the energy provided, payment conditions etc.

The text may suggest that there is a single energy exchange – such as offered by APX-ENDEX. In practice however, there may be many locations where energy is traded ranging from national level energy exchanges, to local energy exchanges, from public exchanges to private exchanges.

4.5.3 Metering & billing view

The energy exchange is not listed in the metering and billing view (Figure 6) because it is not participating in any physical exchanges of energy. The energy exchange role is only concerned with establishing contracts between different parties and is as such only visible in the commercial view.

Information about established contracts will be sent to all relevant parties (which could be the billing departments of the trader or producer or a 3rd party billing service). The billing departments will have to use such contract data and collected metered data (from metering responsible party) to

determine how much money is involved in each contract, and will have to determine how to collect and/or pay the money owed.

The energy exchange is likely to have a certain compensation model to cover its operational costs. Both traders and retailers have to pay a fee for using the energy exchange services.

Note that in today's market organization, the market place is to a significant extent formed by the Amsterdam Power eXchange. However, APX-ENDEX[13] functions not only as a trading platform, but also as a financial clearinghouse, clearing all trades anonymously and "requiring members to lodge collateral in the form of cash or letters of credit – in excess of outstanding exposure at all times". It only supports trades of a certain minimum volume (for example spot block orders are traded in lots of 0.1 MWh, which is way more than the volumes which would be relevant for typical households).

4.6 Transmission System Operator (TSO)

4.6.1 Physical view

The Transmission System Operator is responsible for the high voltage transmission grid. A TSO has the following tasks:

- **Transport of electricity**. The purpose of the transmission grid is to transport electricity from the producers to the consumers via a high voltage electricity grid. Some of the end users are directly connected to the transmission grid (large producers and consumers), but most of the end users are indirectly connected via a medium and low voltage grid.
- **Maintenance and expansion of the grid**. As our society has become increasingly dependent on electricity the security of supply is very important. Therefore proper maintenance of the grid is essential to avoid outages as much as possible. The TSO also has to make sure that the capacity of the grid is in line with current and future needs. Developing an offshore wind mill park, for example, will also require an expansion of certain parts of the transmission grid.
- **Balancing of production and consumption.** Balancing is necessary to ensure security of supply on the short term.
  The first step of the balancing process is that all balance responsible parties provide a schedule to the TSO specifying the amount of energy they will produce or consume on their connections to the grid for each 15 minute time slot. When these schedules are consistent they will be approved.
  The second step of the balancing process takes place during the actual dispatch of electricity. Whenever imbalance occurs on the grid the TSO asks specific producers to produce more or less energy, or specific consumers to consume more or less, depending on whether there is a shortage or a surplus of electricity.

4.6.2 Commercial view

The TSO already made agreements in advance with specific producers (with a minimum production capacity) and consumers to reserve part of their capacity for managing imbalances. These parties are being paid by the TSO for both reserving their power and their actual production and consumption reduction respectively for reducing imbalance.

[13] http://www.apxendex.nl/uploads/Corporate_Files/Data_sheets/APX_Power_NL_data_sheet_1-2012.pdf

4.6.3 Metering & billing view

The description of the balancing process is not complete without the process for settling the costs the TSO has to make. The balance responsible parties have to cover for these costs in two ways: (1) the system costs (a fee that is being paid for usage of the grid) and (2) fines for not having met the schedule that was communicated to the TSO. These fines can be quite significant and are an important incentive for balance responsible parties to make sure that they meet their schedules. In addition, balance responsible parties may receive bonuses for contributing to imbalance reduction.

At various relevant physical interfaces in the networks, such as connection points where consumers and producers are connected, and interconnection points with other TSO's, meters are installed providing detailed information about the energy flows at that interface.

Apart from the balancing process, the TSO also charges all parties that are connected to its transmission grid a fee for the transport of electricity.

4.7 Balance Responsible Party (BRP)

Balance responsible party is a role with a legal status, as defined in the electricity act and the system code [Systemcode]. To operate in the Netherlands, a balance responsible party must have a license granted by the national TSO (in the Netherlands: TenneT).

On the Dutch network, multiple balance responsible parties are active at the same time.

4.7.1 Physical view

The balance responsible party does not require physical relations.

4.7.2 Commercial view

Retailers and traders trade energy on the energy market, which should result in a balanced situation of supply and demand on the energy market. A balance responsible party combines the supply and demand and organizes (plan construction & plan execution) the logistics – on the transmission system operated by the TSO - of each trade.

Plan construction

A balance responsible party creates a plan, by combining all expected energy schedules from (its) retailers (for consumption schedules) and (its) traders (for proposed production schedules). Such a plan is known as an overall energy schedule and is derived from all supply and demand on the energy exchange. All Balance Responsible Parties offer their plan to the TSO for verification.

The TSO checks all plans (combined schedules) for consistency: balance responsible parties can offer "internally consistent" schedules (schedules where consumption and production of energy is balanced within the schedule), or they can offer "externally" consistent schedules (where a combination of internally non consistent schedules, when combined, turns out to be consistent).

If the TSO accepts the schedules offered, the balance responsible parties (and the associated producers and consumers) are expected to execute their plans (which includes both scheduled production and consumption of energy).

Often, balance responsible parties provide this service to many small retailers and traders, and as such they acquire a certain scale.

Plan execution

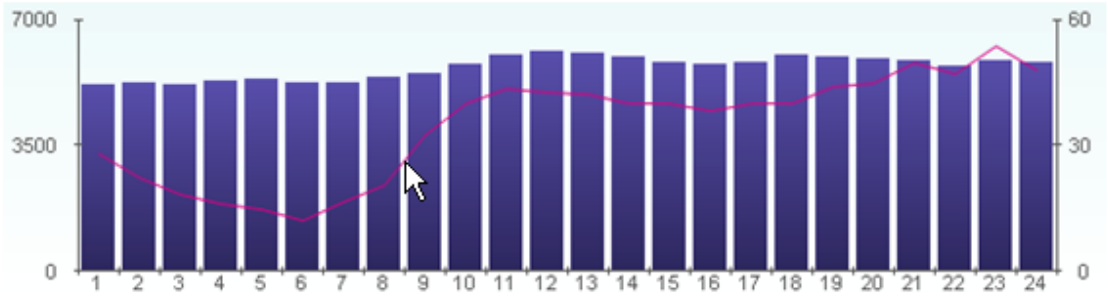
The Balance Responsible Parties are responsible for execution of the proposed and committed schedule. If the BRP detects a deviation from his schedule the BRP will tune the demand and supply under his control to be consistent again with his schedule.

MATCHING RESULTS APPLYING DATE: 09-06-2012

APX INDICES FOR THE HUB NL

	Average Price	Net Volume
Base	€ 34.79	135996.7 MWh
Peak	€ 40.70	70694.4 MWh
Off-Peak	€ 28.89	65302.3 MWh

APX HOURLY DETAILS FOR THE HUB NL



	1	2	3	4	5	6
Net Volume (MWh)	5201.0	5222.1	5184.8	5279.9	5326.1	5247.2
Price (€)	28.01	22.27	18.40	15.86	14.54	12.18
	7	**8**	**9**	**10**	**11**	**12**
Net Volume (MWh)	5245.1	5370.6	5504.4	5748.9	6023.3	6105.5
Price (€)	16.36	20.31	32.43	39.93	43.77	42.79
	13	**14**	**15**	**16**	**17**	**18**
Net Volume (MWh)	6071.3	5944.7	5822.3	5762.9	5822.7	6006.8
Price (€)	42.44	39.94	39.93	38.00	39.93	40.12
	19	**20**	**21**	**22**	**23**	**24**
Net Volume (MWh)	5959.7	5921.9	5885.1	5718.8	5833.7	5787.9
Price (€)	44.15	44.94	50.00	47.00	53.79	47.97

Figure 7: Typical price and volume scheme of a 24 hour trading cycle on the APX – prices range from 12.18 € to 53.79 € per MWh – a significant price difference

The BRP can correct any imbalance that may occur during execution of their plans up to 90 minutes before actual execution of that plan; and the smallest block of trade covers one hour in time. Such short term trading is done on the Balance market (figure 5).

If the imbalance occurs less than 90 minutes before the execution of the plan the BRP is no longer allowed to act: the TSO takes over the responsibility for correcting the imbalance. At that moment the Transmission System Operator has to trade the surplus or shortage of energy at a short term, in order to prevent imbalance and/or to restore balance. In that case the TSO will call upon producers and consumers to activate their reserved capacity.

4.7.3 Metering & billing view

As with all the other parties in the Flexines role model, metering and contractual data is collected, which is being used for billing (financial reconciliation) through the billing responsible party.

The BRP gets paid for successfully executing the agreed upon plan; bonuses and fines are added based on the BRP's role in causing or reducing imbalance.

4.7.4 Billing responsible party in the real world

The role of the Balance Responsible Party can be fulfilled by basically any party, but traditionally traders and retailers are playing this role. With increasing (small scale) local energy initiatives (for both production and consumption), more and more parties start to offer balance responsible party services (as their core business) to such local energy initiatives. A growing role is foreseen for the TSO in balancing at a local level.

4.8 Balance Market

Normally, energy trading for specific timeslots takes place – up to 90 minutes in advance of executing the actual plan for that timeslot – on the energy exchange (section 4.5). Whenever production and consumption of electricity are out of balance (at or just before real time), the TSO has to act to restore the balance.

4.8.1 Physical view

The TSO itself has no means to increase production or decrease consumption[14], but it asks large producers or consumers to intervene – using the reserved spare capacity. There are three levels of intervention: primary, secondary and tertiary control.

- A primary control production plant reacts automatically to a change in frequency (sub minute response times).
- Secondary control is also aimed at restoring frequency but in this case a production plant is instructed by the TSO instead of an automatic response.
- Tertiary control is used when an imbalance is already known in advance, for example when a forecast turns out to be wrong.

4.8.2 Commercial view

As already described in section 4.2.2, large producers and consumers must offer reserve capacity to the TSO. A balance responsible party plays no role on this market. The TSO pays these producers and

14

http://www.energiened.nl/_upload/bestellingen/publicaties/00000212.pdf - een helder marktmodel voor klant en energiesector.

consumers both for reserving their capacity and for the actual usage of their reserved capacity when balancing is required.

4.8.3 Metering & billing view

The TSO pays the participants on the balance market for reserving their capacity and the actual capacity that was used. Generally the prices are higher than the average prices on the long term and day ahead market.

4.9 Distribution System Operator (DSO)

4.9.1 Physical view

The DSO owns regional medium and low voltage grids. The DSO connects consumers to the grid. It is their responsibility to ensure that the distribution grid is as reliable as possible.

Currently a DSO does not have to balance its network. This is all taken care of on the transmission level by the TSO. The DSO however has a legal requirement to have sufficient capacity on its network to transport all the electricity from and to the end-users.

The risk of overloading the grid increases because of two trends: electrification and Distributed Energy Resources (DER). Examples of electrification are Electrical Vehicle Charging and the use of heat pumps. Distributed Energy Resources such as Combined Heat and Power (CHP) and PV panels can put additional stress on distribution grids when they are rolled out in large numbers. In order to prevent the grid from overstressing, load/capacity management – and power quality management - will become increasingly important for DSO's.

4.9.2 Commercial view

The services that a DSO offers are strictly regulated as well as the costs of provided services, where prices are benchmarked against other DSO's to make sure that they operate efficiently.

Increasing the capacity of the network can be quite a costly affair. For that reason implementation of for example demand side management (DSM) can be very interesting for a DSO. With DSM DSOs can send varying price incentives to consumers, thus stimulating them to shift their energy usage from peak hours towards off-peak hours. Using a connection during peak hours will become more costly than using it during off-peak hours (i.e. peak pricing or time-of-use pricing). It has the potential to postpone investments in the infrastructure by using it more efficiently (peak shaving). Other pricing schemes for flexible transport costs can be envisioned, e.g. distance based.

4.9.3 Metering & billing view

Meters are part of the infrastructure of a DSO. The metering responsible party makes sure that the metering data is read.

The fee for the DSO services (grid connection for producers and consumers) can either be paid via the retailer, or directly to the DSO.

4.10 Energy Service Provider

The Energy Service Provider (ESP) is a new role in the value network that will become more and more important in the future. The ESP offers value added services, on top of energy (gas, electricity, heat) as a commodity service. Examples of value added services are:

- a portal, which provides consumers insight in their energy usage/behavior
- prediction of future generation capacity based on weather forecasts
- management and control of the smart energy hub within a household
- benchmark service, which compares energy usage/production with similar households
- services that support local energy exchange between local producers and local consumers
- advice services, that send alarm signals whenever energy usage of in-home appliances operate different from what was scheduled;
- maintenance services.

Typically these services are offered by companies that are traditionally not part of the energy value network. Many of the value added services being offered will be ICT based.

4.10.1 Physical view

The Energy Service Provider does not have a physical connection with other roles through the energy infrastructure, but there is a connection via an ICT network.

4.10.2 Commercial view

The ESP offers services to consumers, both at a household level and small and medium enterprises. The services can be offered as separate products, where a consumer takes services from multiple ESPs, but also packaging is an option where a consumer gets all his services from one ESP. The commercial relation is established in a contract between the ESP and the consumer. Services can be contracted on a one-time fee, or via a subscription model, or it can even be based on performance indicators which are described in a contracted Service Level Agreement (SLA).

4.10.3 Metering & billing view

While services are intangible, metering is out of order. Billing and reconciliation is done based on the contractual arrangements.

4.11 Metering Responsible Party

Metering services are regulated services.

4.11.1 Physical view

At various points within the networks, meters are installed to measure the amount of energy consumed or produced. Such meter data is collected by a metering responsible party (MRP).

4.11.2 Commercial view

An important part of each commercial contract will be based on the supply of a specific amount of energy in a specific time frame. Metered data will be needed that is equal to or smaller than the timeframes specified in each contract.

For example, if time-of-day pricing is used with varying prices for specific timeslots, then meter data will be needed that aggregates data to match the timeslots specified in the contract[15]. Such aggregates should be provided by the MRP.

[15] In the Netherlands, many customers use peak/off-peak pricing schemes. This is typically implemented by two meters, one which counts the energy used during peak hours, the other which counts energy during off-peak hours.

4.11.3 Metering & billing view

The MRP aggregates the metered data – at the required level of detail - and distributes the resulting aggregated meter data to the different roles. Those roles use that data for operational and planning purposes (System Operators and Balance Responsible Parties), for billing and reconciliation purposes (billing responsible parties, retailers and traders). Consumer and producer roles could use the meter data to gain insight into the energy produced and consumed in their households.

4.12 Billing Responsible Party

4.12.1 Physical view

The billing responsible party does not have any physical connections to the grids.

4.12.2 Commercial view

Energy contracts are established between sellers and buyers. The billing responsible party governs the delivery from supplier to consumer and the exchange of money from consumer to supplier for a specific timeframe (for example, one year). The actual amount of energy exchanged as established by the metering responsible party will be used to calculate the amount of money that the consumer owes the supplier. Both parties need to honor their part of the contract; otherwise, contracts for subsequent time periods will not be established (resulting in the consumer not getting energy in the future)[16].

4.12.3 Metering and billing view

For billing purposes, metering data will have to be available at the right aggregation levels. The same data may have to be provided to both the receiver and the sender of the invoice to allow them to (1) establish the invoices in the first place but also (2) to verify the correctness of the invoices. In case the invoices are not correct, the consumer is likely to file a complaint about the invoice, and will simply not pay the invoice. In such a situation the supplier has to be able to verify the correctness of the invoices, and should have procedures in place to handle challenges on the complete invoice or on specific items on the invoice.

Once invoices are exchanged, the consumer should pay the money owed within the contractually established timeframes (and taking into account potential other payment conditions). Note that the consumer's payment or invoicing behavior will influence the establishment of future energy contracts: if a consumer does not pay his invoices in time or if a supplier continuously sends incorrect invoices, it is unlikely that future energy contracts will be established between these parties.

In the Flexines role model, the concept could be that certain participants are excluded – for a specific time frame - from participating in the energy market.

5 Reflection

This paper presents the Flexines role model of a future energy market, using the ENTSOE and TenneT models as important points of reference. The Flexines model refers to many of the same concepts of

[16] Legal requirements may exist which do not allow consumers to be cut off from the network, still allowing them to consume energy even though no contract is established. In the Flexines model, in such situations the consumer would be using energy from the "supplier of last resort" at quite possibly unfavorable prices. If the consumer does not pay his invoices, the claim of the "supplier of last resort" will grow in size, and special collection measures will have to be taken.

the ENTSOE and TenneT role model, but at the same time it gives its own interpretation[17] and sometimes extensions. This includes households actively selling and buying energy on the market.

It should be noted that one of the key differences is that ENTSOE and TenneT aim to describe the current situation, whereas Flexines needs a model that describes a potential future situation of the energy market.

5.1 Suitability of ENTSOE and TenneT role models

The Flexines model focuses on subsets of the ENTSOE and TenneT models, specifically, aspects related to connecting households (or groups of households) to energy distribution networks. It provides the physical, the commercial and the metering & billing views.

To a large extent, many of the roles in the ENTSOE, TenneT and Flexines models correspond. Flexines recognizes one role which cannot be found in either ENTSOE or TenneT: the Energy Service Provider. We expect such service providers to be important "value adders" in future energy markets. ENTSOE and TenneT could easily adopt this new role.

An example of such an ESP is a Virtual Power Plant: Virtual Power Plants are being investigated as a new concept for organizing the energy produced by a collection of many small producers. A VPP could be implemented by a consumer community which forms a micro-grid, as described in section 4.1.4.

As a conclusion, the Flexines model matches the ENTSOE and TenneT models quite well and suggests an extension.

5.2 Analysis of ENTSOE and FLEXINES concepts

The Flexines model was used to analyse the concepts that are key to the Flexines project, such as: local energy production patterns, predictions, variable tariffs, local energy trading, local matching of consumption and production etc. So the next step is to investigate whether the concepts in Flexines are also in line with the ENTSOE and TenneT models. The following paragraphs analyze these concepts one by one.

- Within Flexines we anticipated on **local energy exchanges**, for example on street or city area level. The current ENTSOE models does not really support such a concept. This is because the energy exchange operates at the level of a transmission system operator which is not acting on the local level (which is the DSO's responsibility).
- **Active trading:** Consumer level contracts based on 15 minute time intervals instead of the usual yearly retail contracts. Currently it is not possible for households to trade in 15 minute time slots. However there is no fundamental reason why there couldn't be energy trading based on such short time slots. The current energy system needs to be adapted for that in order to provide the required flexibility.
- **New standard products:** The ENTSOE model only indicates that a Balance Responsible Party deals within a Market Balance Area, it does not specify particular energy products that are traded. However, Flexines envisions different standard energy products to be traded. For

[17] Note: for many parts of the ENTSOE model, the explanations provided are not precise enough, forcing future projects to produce their own interpretations and models.

example, yearly, weekly, daily or 15 minute timeslot contracts (on specific energy patterns for those time periods).

- **New trading process:** Parties connected to the grid can request energy quotations from several potential balance suppliers. The Flexines concept is also in line with the ENTSOE model. Such price quotations may have very different prices (resulting in variable energy prices).
- **Variable transport tariffs:** ENTSOE recognizes transport tariffs, but does not prescribe a particular format of the transport tariff or calculation method. A variable transport tariff is therefore considered to be compatible with ENTSOE.
- **Neighbor-2-neighbor:** Trading between two neighbors is in principle possible. Within the context of the ENTSOE model this means that both neighbors have to play the role of a balance responsible party to be able to trade. Although parties may be allowed to function as balance responsible party, for normal households this would currently be very difficult due to various legal requirements posed to balance responsible party. An alternative would be that such households obtain the services from an existing balance responsible party.
- **The importance of forecasting to energy operations:** ENTSOE does not explicitly recognize forecasting, it would primarily be seen as a problem for the balance responsible party. In general however, forecasting is important to many parties in the ENTSOE model. Forecasting is a good example of an important value added service that can be offered by an Energy Service Provider.

6 Conclusions and food for thought

The current energy system is facing major challenges; increasing demand, increasing accommodation of renewable and decentralized energy production, and changing market structure and regulation. The current energy system must constantly evolve in order to cope with these challenges.

The Flexines project studied a possible future role model of the energy system. The project effectively only used a subset of models provided by ENTSOE and TenneT, but this subset needs to be extended and modified in order to meet the requirements the future market situation, as projected by the Flexines project. This paper identifies and motivates the required extensions (role of the Energy Service Provider), but it also addresses a number of aspects (commercial, physical and billing related) that are typically not part of the current ENTSOE and TenneT models.

ENTSOE and TenneT offer a good structure of how the market is organized, but developments such as outlined within the Flexines project, will need to be incorporated. ENTSOE and TenneT provide insufficient answers on certain smart grids development, such as decentralized production, and trading by households. The Flexines concepts fit in the structure offered by ENTSOE, but the necessary mechanisms – and even an important role the Energy Service Provider cannot be found in ENTSOE. Within ENTSOE, care must be taken to develop the model so that it does not only describe the current situation and the past, but also that it is prepared for the future. This report can be used as input for the discussion with both TenneT and ENTSOE.

7 Literature

[1] TenneT: “Energy in the Netherlands 2011”, section 2 pages 14 – 21.

[2] ENTSOE: “The harmonized Electricity Market Role Model”, version 2011-01.

[3] APX: http://www.apxendex.nl/

[Systemcode]: NMa - Energiekamer (2012), Systeemcode Elektriciteit, 14 maart 2012, retrieved from http://www.nma.nl/images/Systeemcode%20elektriciteit%20per%2014%20maart%20201222-197663.pdf